

CLAIMS

What is claimed is:

1. A method for *in vitro* polymerization of silica and silicone polymer networks, comprising:
 - (a) combining a catalyst and a substrate, wherein the substrate is selected from the group consisting of silicon alkoxide, metal alkoxide, and organic conjugates of the foregoing; and
 - (b) polymerizing the substrate to form silica, polysiloxanes, polymetalloxanes, or mixed poly(silicon/metallo)oxane materials at about neutral pH.
2. The method of claim 1, wherein the substrate is a silicon alkoxide having the general formula $R-Si-(O-Et)_3$, wherein Et is ethyl and R is methyl, phenyl, or ethoxy.
3. The method of claim 2, wherein the polymerized materials include a polysilsesquioxane having the general formula $(RSiO_{3/2})_n$, wherein n is an integer greater than 1.
4. A composition for use in polymerizing silica and silicone polymer networks, said composition comprising:
 - (a) a silicon alkoxide substrate; and
 - (b) a catalyst that assembles, hydrolyzes, and condenses the substrate at about neutral pH.
5. A catalyst comprising a protein or polypeptide that assembles, hydrolyzes, and condenses silicon alkoxides at about neutral pH.
6. The catalyst of claim 5, wherein the protein or polypeptide is selected from the group consisting of silicatein filaments, silicatein subunits, cysteine homopolymers, and cysteine-containing block copolypeptides.

7. The catalyst of claim 5 wherein the catalyst is a protein comprising an amino acid sequence at least 70% identical to SEQ ID NO:1.

8. The catalyst of claim 5 wherein the catalyst is a recombinant protein encoded by a nucleotide sequence at least 70% identical to the coding regions of SEQ ID NO:2.

9. The catalyst of claim 5 wherein the catalyst is cysteine-containing block copolypeptide selected from the group consisting of poly(L-Cysteine₁₀-*b*-L-Lysine₂₀₀), poly(L-Cysteine₃₀-*b*-L-Lysine₂₀₀), poly(L-Cysteine₆₀-*b*-L-Lysine₂₀₀), and poly(L-Cysteine₃₀-*b*-L-Lysine₄₀₀).

10. A silicified structure synthesized according to the method of claim 1, said structure assuming a shape determined by the catalyst, wherein the catalyst includes a scaffolding function directing the shape of the structure.

11. A silicified structure synthesized according to the method of claim 1, said structure assuming a shape selected from the group consisting of filaments, spheres, elongated globules, and columns.